US009311512B2

(12) **United States Patent**
Gurumoorthy et al.

(10) **Patent No.: US 9,311,512 B2**
(45) **Date of Patent: *Apr. 12, 2016**

(54) **APPARATUS AND METHOD TO HARDEN COMPUTER SYSTEM**

(71) Applicant: **Intel Corporation**, Santa Clara, CA (US)

(72) Inventors: **Naga Gurumoorthy**, Portland, OR (US); **Arvind Kumar**, Beaverton, OR (US); **Matthew J. Parker**, Hillsboro, OR (US)

(73) Assignee: **Intel Corporation**, Santa Clara, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **14/450,607**

(22) Filed: **Aug. 4, 2014**

(65) **Prior Publication Data**

US 2014/0344961 A1 Nov. 20, 2014

Related U.S. Application Data

(63) Continuation of application No. 13/404,628, filed on Feb. 24, 2012, now Pat. No. 8,819,857, which is a continuation of application No. 12/286,352, filed on Sep. 30, 2008, now Pat. No. 8,132,267.

(51) **Int. Cl.**

G06F 11/00 (2006.01)
G06F 21/88 (2013.01)

(Continued)

(52) **U.S. Cl.**

CPC ***G06F 21/88*** (2013.01); ***G06F 9/4401*** (2013.01); ***G06F 21/575*** (2013.01); ***G06F 21/73*** (2013.01); *G06F 9/44542* (2013.01); *G06F 2221/2141* (2013.01)

(58) **Field of Classification Search**

CPC G06F 21/00; G06F 21/88; G06F 9/4401; G06F 21/575; G06F 21/73; G06F 2221/2141; G06F 9/44542

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,275,933 B1 8/2001 Fine et al.
7,100,036 B2 8/2006 Schwartz

(Continued)

FOREIGN PATENT DOCUMENTS

CN 101714200 A 5/2010

OTHER PUBLICATIONS

Non-Final Office Action received for U.S. Appl. No. 12/286,352, mailed on Jul. 11, 2011, 6 pages.

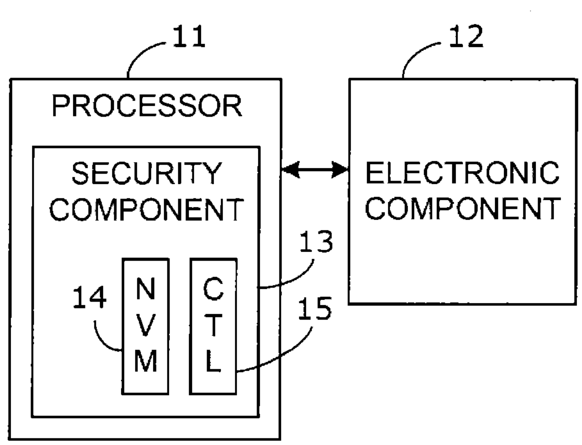
(Continued)

Primary Examiner — Krisna Lim
(74) *Attorney, Agent, or Firm* — Jordan IP Law, LLC

(57) **ABSTRACT**

In some embodiments, a processor-based system may include a processor, the processor having a processor identification, one or more electronic components coupled to the processor, at least one of the electronic components having a component identification, and a hardware security component coupled to the processor and the electronic component. The hardware security component may include a secure non-volatile memory and a controller. The controller may be configured to receive the processor identification from the processor, receive the at least one component identification from the one or more electronic components, and determine if a boot of the processor-based system is a provisioning boot of the processor-based system. If the boot is determined to be the provisioning boot, the controller may be configured to store a security code in the secure non-volatile memory, wherein the security code is based on the processor identification and the at least one component identification. Other embodiments are disclosed and claimed.

6 Claims, 6 Drawing Sheets



(51) **Int. Cl.**

G06F 21/57	(2013.01)
G06F 21/73	(2013.01)
G06F 9/44	(2006.01)
G06F 9/445	(2006.01)

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,207,039	B2	4/2007	Komarla et al.
7,392,371	B2	6/2008	Zimmer et al.
7,493,460	B2	2/2009	Zimmer et al.
7,594,104	B2	9/2009	Dale et al.
7,757,098	B2	7/2010	Brannock et al.
7,779,273	B2	8/2010	Dale et al.
7,783,886	B2	8/2010	Walmsley
7,822,979	B2	10/2010	Mittal
7,940,932	B2	5/2011	Paksoy et al.
8,132,267	B2	3/2012	Gurumoorthy et al.
8,819,857	B2	8/2014	Gurumoorthy et al.
2003/0018923	A1	1/2003	Kumar et al.
2007/0192824	A1	8/2007	Frank et al.
2008/0229092	A1	9/2008	Dale et al.
2008/0244257	A1	10/2008	Vaid et al.
2008/0250250	A1	10/2008	Westerinen et al.
2009/0307478	A1	12/2009	Gehrmann
2010/0083365	A1	4/2010	Gurumoorthy et al.
2011/0154032	A1	6/2011	Mauro, II

OTHER PUBLICATIONS

Notice of Allowance received for U.S. Appl. No. 12/286,352, mailed on Oct. 27, 2011, 9 pages.

Non-Final Office Action received for U.S. Appl. No. 12/587,825, mailed Jan. 24, 2012, 5 pages.

Notice of Allowance received for U.S. Appl. No. 13/404,628, mailed on Apr. 23, 2014, 7 pages.

Non-Final Office Action received for U.S. Appl. No. 13/404,628, mailed on Dec. 19, 2013, 11 pages.

Office Action received for Chinese Patent Application No. 200910204981.0, mailed on May 16, 2012, 3 pages of office action and 4 pages of English Translation.

Office Action received for Chinese Patent Application No. 200910204981.0, mailed on Oct. 18, 2011, 6 pages of office action and 6 pages of English Translation.

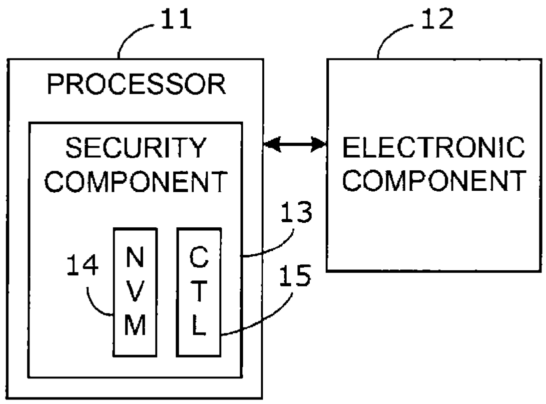


Fig. 1

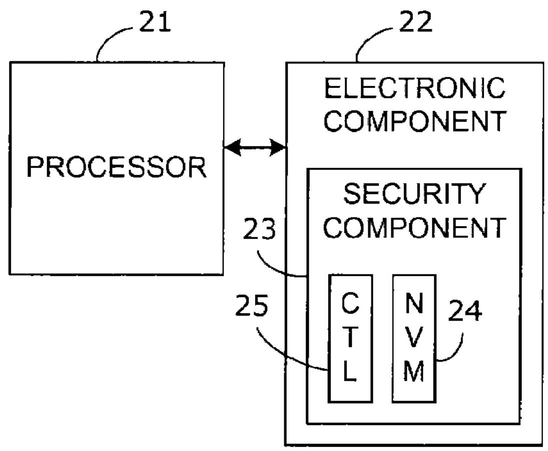


Fig. 2

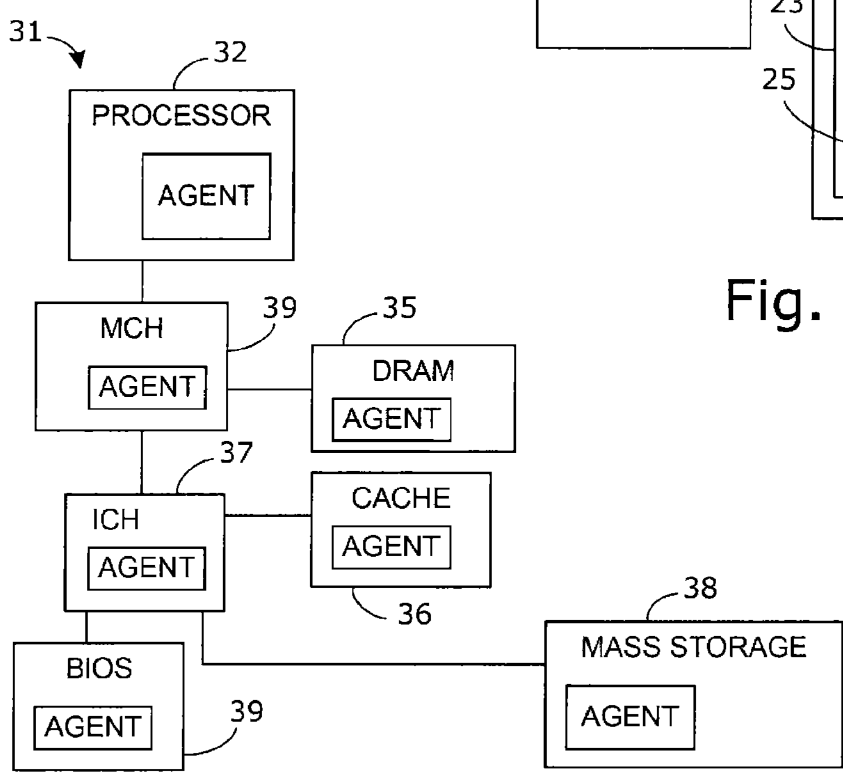


Fig. 3

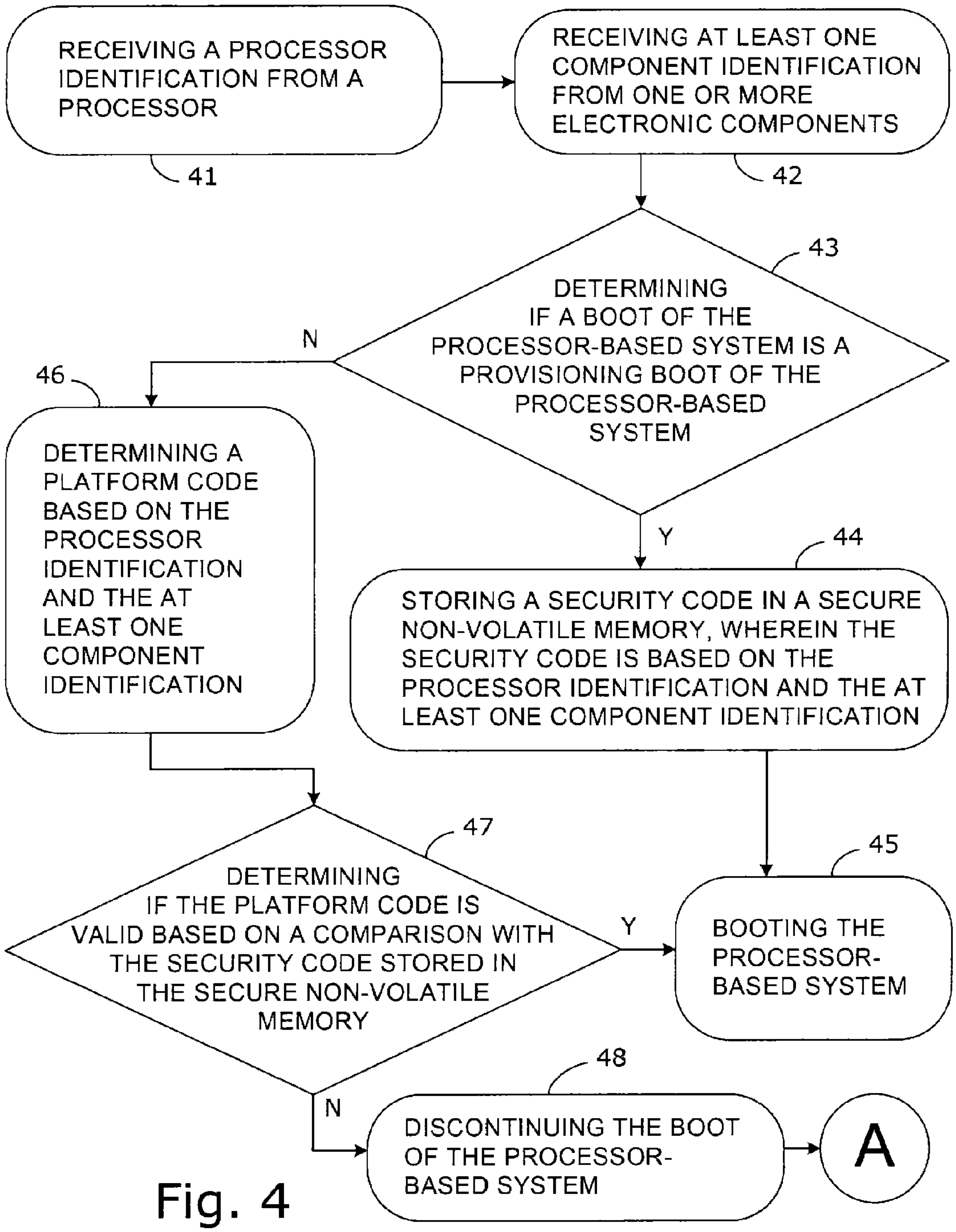

RECEIVING A PROCESSOR IDENTIFICATION FROM A PROCESSOR
41
RECEIVING AT LEAST ONE COMPONENT IDENTIFICATION FROM ONE OR MORE ELECTRONIC COMPONENTS
42
43
DETERMINING IF A BOOT OF THE PROCESSOR-BASED SYSTEM IS A PROVISIONING BOOT OF THE PROCESSOR-BASED SYSTEM
N
46
DETERMINING A PLATFORM CODE BASED ON THE PROCESSOR IDENTIFICATION AND THE AT LEAST ONE COMPONENT IDENTIFICATION
Y
44
STORING A SECURITY CODE IN A SECURE NON-VOLATILE MEMORY, WHEREIN THE SECURITY CODE IS BASED ON THE PROCESSOR IDENTIFICATION AND THE AT LEAST ONE COMPONENT IDENTIFICATION
47
DETERMINING IF THE PLATFORM CODE IS VALID BASED ON A COMPARISON WITH THE SECURITY CODE STORED IN THE SECURE NON-VOLATILE MEMORY
Y
45
BOOTING THE PROCESSOR-BASED SYSTEM
48
N
DISCONTINUING THE BOOT OF THE PROCESSOR-BASED SYSTEM
A

Fig. 4

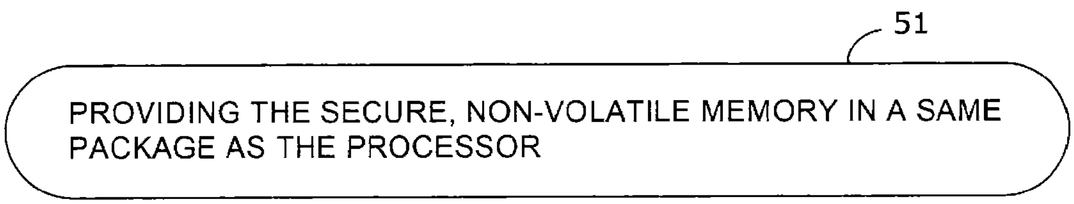


Fig. 5

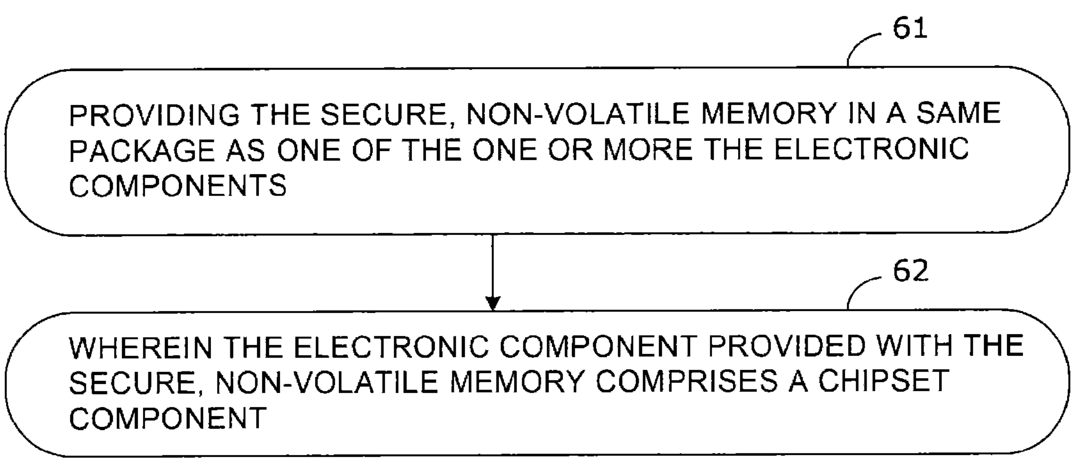


Fig. 6

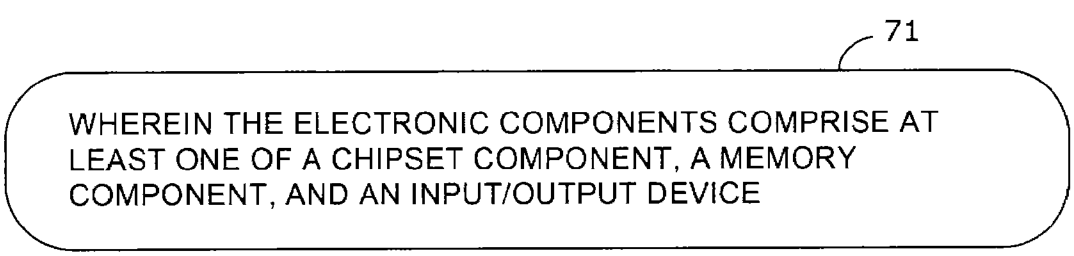


Fig. 7

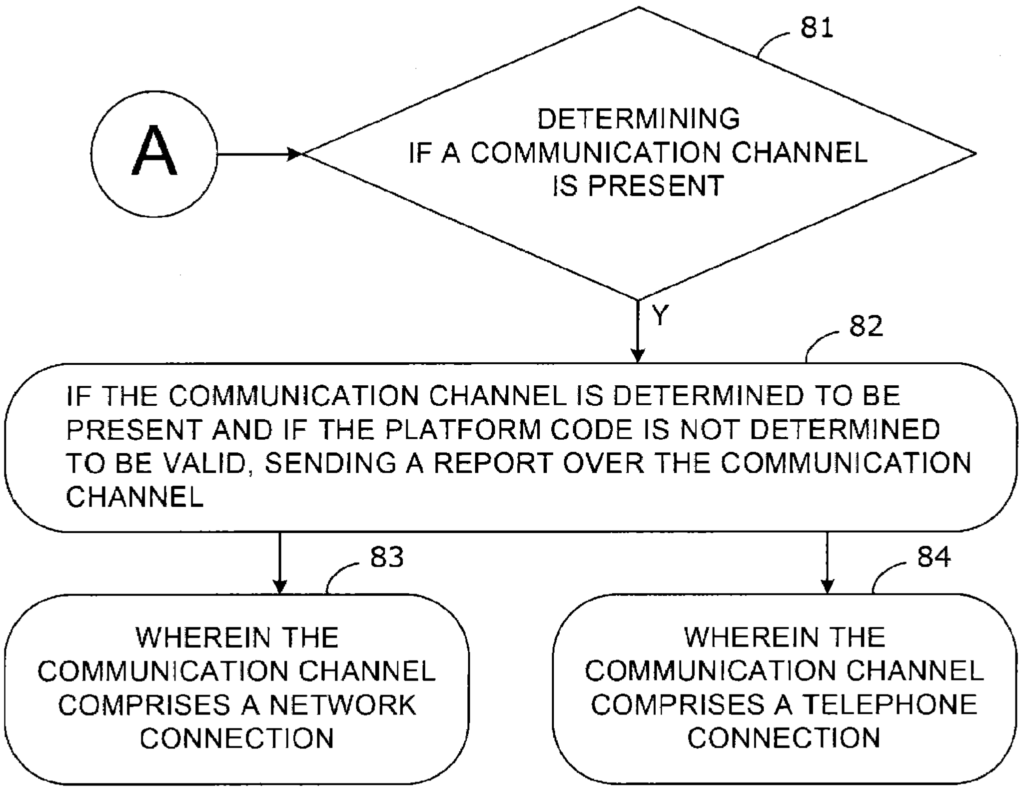

81
A
DETERMINING
IF A COMMUNICATION CHANNEL
IS PRESENT
Y
82
IF THE COMMUNICATION CHANNEL IS DETERMINED TO BE PRESENT AND IF THE PLATFORM CODE IS NOT DETERMINED TO BE VALID, SENDING A REPORT OVER THE COMMUNICATION CHANNEL
83
WHEREIN THE COMMUNICATION CHANNEL COMPRISES A NETWORK CONNECTION
84
WHEREIN THE COMMUNICATION CHANNEL COMPRISES A TELEPHONE CONNECTION

Fig. 8

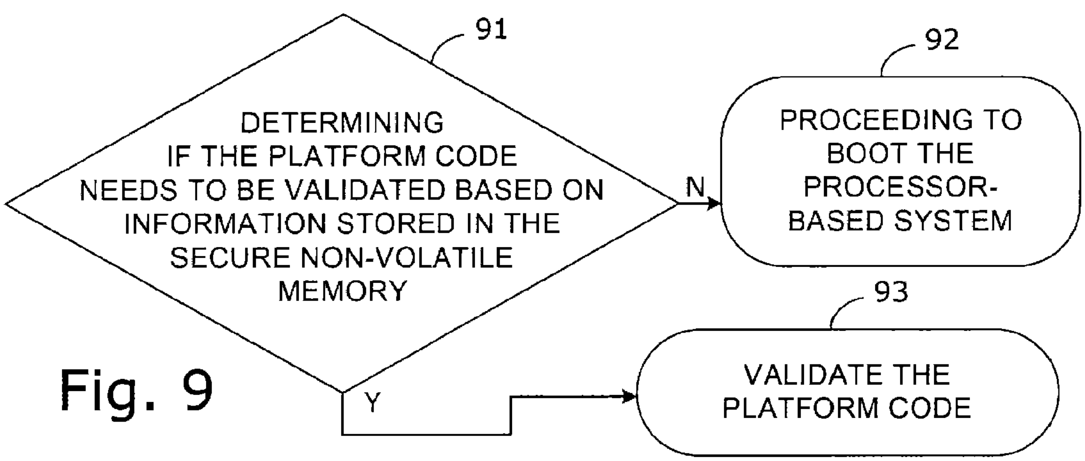

91
DETERMINING
IF THE PLATFORM CODE
NEEDS TO BE VALIDATED BASED ON
INFORMATION STORED IN THE
SECURE NON-VOLATILE
MEMORY
N
92
PROCEEDING TO BOOT THE PROCESSOR-BASED SYSTEM
Y
93
VALIDATE THE PLATFORM CODE

Fig. 9

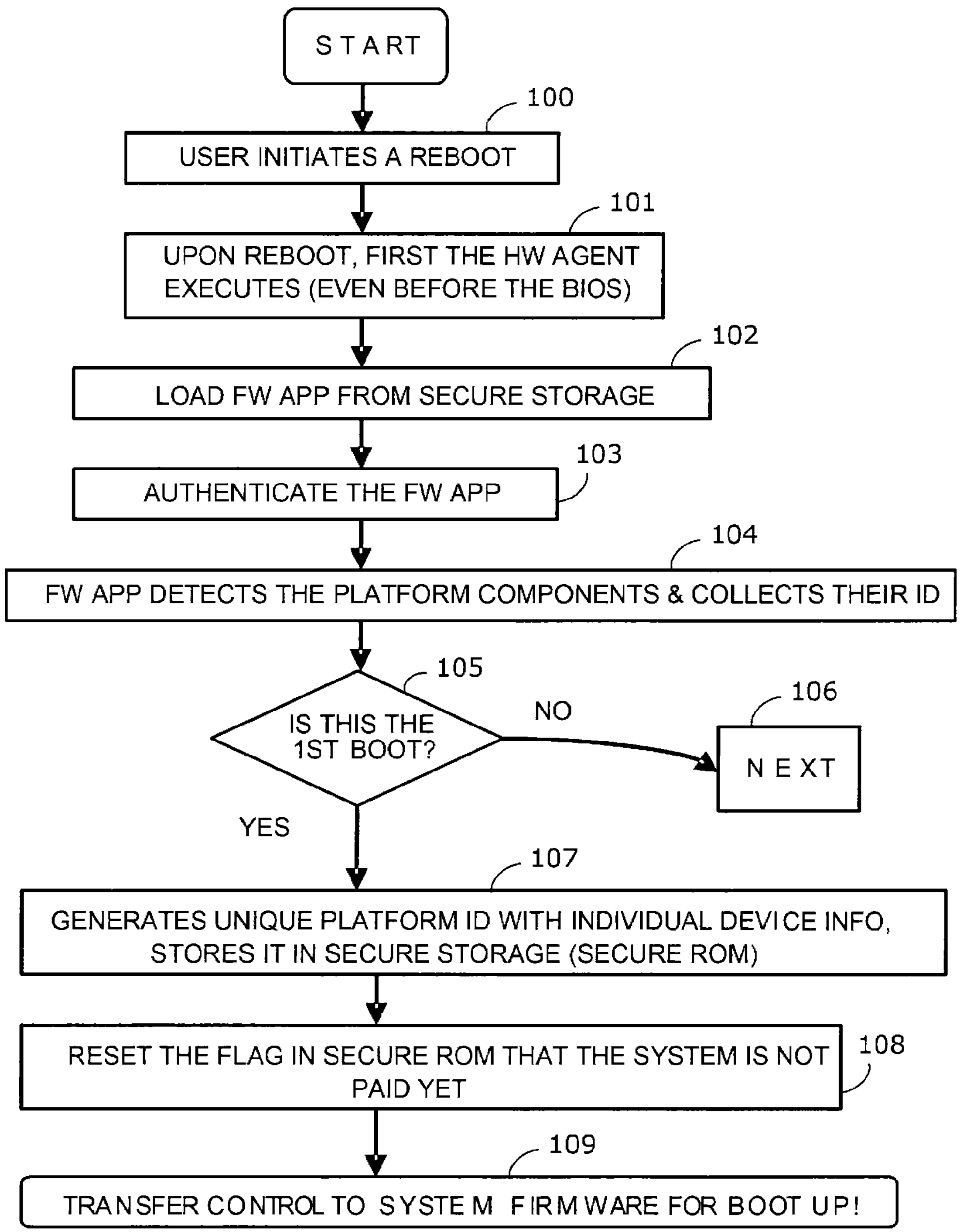

START
100
USER INITIATES A REBOOT
101
UPON REBOOT, FIRST THE HW AGENT EXECUTES (EVEN BEFORE THE BIOS)
102
LOAD FW APP FROM SECURE STORAGE
103
AUTHENTICATE THE FW APP
104
FW APP DETECTS THE PLATFORM COMPONENTS & COLLECTS THEIR ID
105
IS THIS THE 1ST BOOT?
NO
106
NEXT
YES
107
GENERATES UNIQUE PLATFORM ID WITH INDIVIDUAL DEVICE INFO, STORES IT IN SECURE STORAGE (SECURE ROM)
108
RESET THE FLAG IN SECURE ROM THAT THE SYSTEM IS NOT PAID YET
109
TRANSFER CONTROL TO SYSTEM FIRMWARE FOR BOOT UP!

Fig. 10

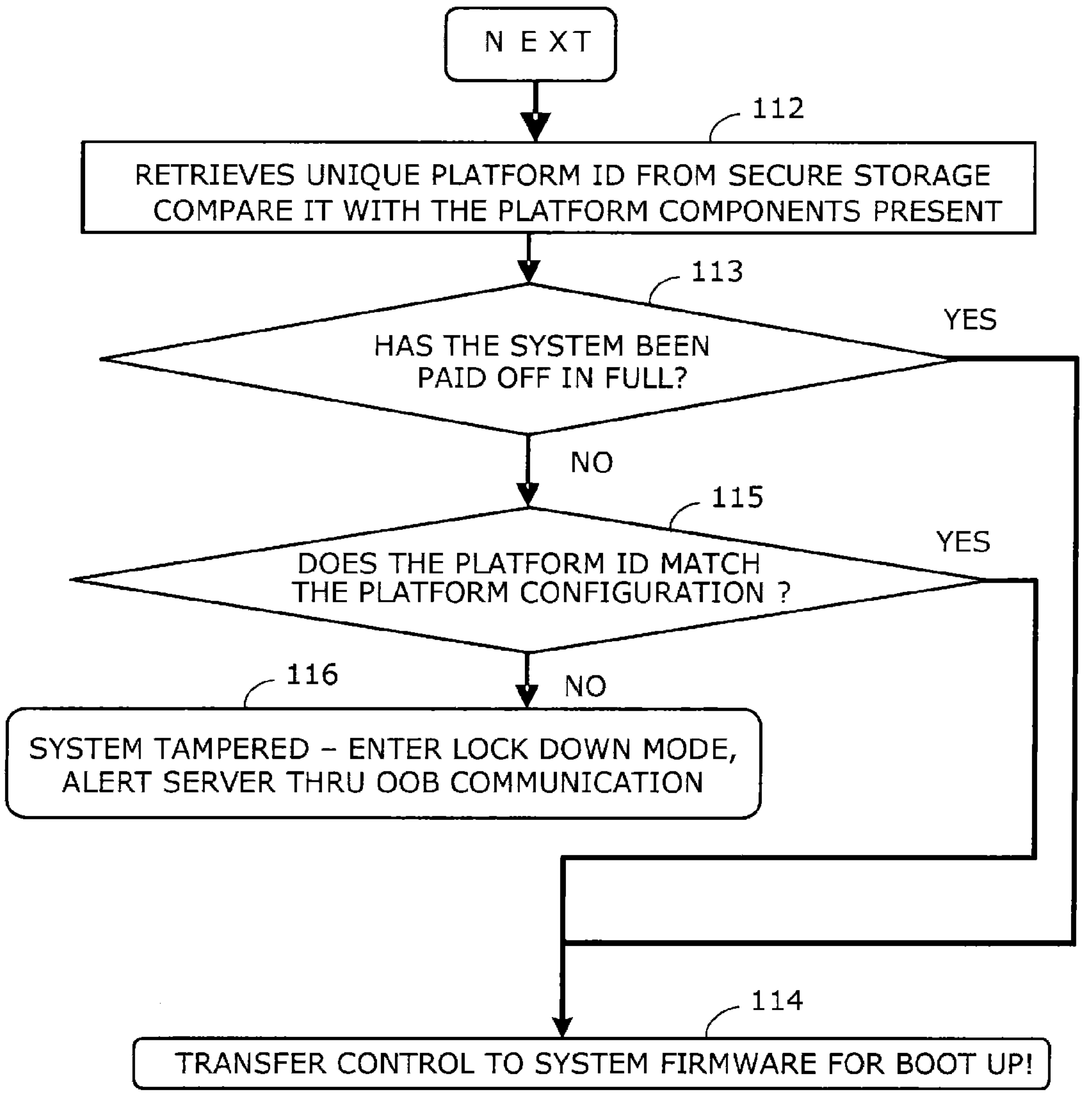

N EXT
112
RETRIEVES UNIQUE PLATFORM ID FROM SECURE STORAGE
COMPARE IT WITH THE PLATFORM COMPONENTS PRESENT
113
HAS THE SYSTEM BEEN
PAID OFF IN FULL?
YES
NO
115
DOES THE PLATFORM ID MATCH
THE PLATFORM CONFIGURATION ?
YES
NO
116
SYSTEM TAMPERED – ENTER LOCK DOWN MODE,
ALERT SERVER THRU OOB COMMUNICATION
114
TRANSFER CONTROL TO SYSTEM FIRMWARE FOR BOOT UP!

Fig. 11

APPARATUS AND METHOD TO HARDEN COMPUTER SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of patent application Ser. No. 13/404,628 filed on Feb. 24, 2012, entitled "APPARATUS AND METHOD TO HARDEN COMPUTER SYSTEM", which issued as U.S. Pat. No. 8,819,857 on Aug. 26, 2014, and which is a continuation of patent application Ser. No. 12/286,352 filed on Sep. 30, 2008, which issued as a U.S. Pat. No. 8,132,267 on Mar. 6, 2012.

TECHNICAL FIELD

The invention relates to hardened computer systems. More particularly, some embodiments of the invention relate to an apparatus and method for deterring theft or unauthorized use of a computer system or computer system components.

BACKGROUND

Some electronic systems may be provided to users on a lease or contract basis. For example, a user may receive the electronic system before the system is completely paid for. While most users will honor the terms of the lease or contract, it may be beneficial to discourage the theft of components or services before the system is paid up. This discouragement of theft or improper tampering with the system may be referred to as hardening.

For example, an electronic system may benefit from hardening against hacking the system, taking components from the system (e.g. for selling in the grey market or using in other systems), switching providers before the contract is fulfilled, and/or cheating the provider by fudging the amount of time used, among other things.

For example, some electronic systems may be hardened by soldering down components (e.g. the processor, chipset, and/or memory components), providing limited expandability (e.g. no PCI slots), using tamper proof screws, using a sealed chassis, employing intrusion detection sensors, using a 6 to 8 layer motherboard (e.g. to cover the traces), and/or epoxying the motherboard surfaces. A problem with these techniques is that they add cost to the manufacturing process (thus increasing the burden on the end users who end up paying more) and they penalize the majority of the users (who are legal, ethical) by limiting the system's capacity and expandability (e.g. the users who are paying in full or have finished the terms of the contract may have limited upgrade ability).

BRIEF DESCRIPTION OF THE DRAWINGS

Various features of the invention will be apparent from the following description of preferred embodiments as illustrated in the accompanying drawings, in which like reference numerals generally refer to the same parts throughout the drawings. The drawings are not necessarily to scale, the emphasis instead being placed upon illustrating the principles of the invention.

FIG. **1** is a block diagram of a processor-based system in accordance with some embodiments of the invention.

FIG. **2** is a block diagram of another processor-based system in accordance with some embodiments of the invention.

FIG. **3** is a block diagram of another processor-based system in accordance with some embodiments of the invention.

FIG. **4** is a flow diagram in accordance with some embodiments of the invention.

FIG. **5** is another flow diagram in accordance with some embodiments of the invention.

FIG. **6** is another flow diagram in accordance with some embodiments of the invention.

FIG. **7** is another flow diagram in accordance with some embodiments of the invention.

FIG. **8** is another flow diagram in accordance with some embodiments of the invention.

FIG. **9** is another flow diagram in accordance with some embodiments of the invention.

FIG. **10** is another flow diagram in accordance with some embodiments of the invention.

FIG. **11** is another flow diagram in accordance with some embodiments of the invention.

DETAILED DESCRIPTION

In the following description, for purposes of explanation and not limitation, specific details are set forth such as particular structures, architectures, interfaces, techniques, etc. in order to provide a thorough understanding of the various aspects of the invention. However, it will be apparent to those skilled in the art having the benefit of the present disclosure that the various aspects of the invention may be practiced in other examples that depart from these specific details. In certain instances, descriptions of well known devices, circuits, and methods are omitted so as not to obscure the description of the present invention with unnecessary detail.

With reference to FIG. **1**, a processor-based system may include a processor **11**, the processor having a processor identification, one or more electronic components **12** coupled to the processor, at least one of the electronic components having a component identification, and a hardware security component **13** coupled to the processor **11** and the electronic component **12**. Example of processor-based systems include but are not limited to desktop computers, laptop computers, nettop computers, netbook computers, mobile internet devices (MIDs), and gaming devices, among numerous other electronic systems.

For example, the electronic components may include at least one of a chipset component, a memory component, and an input/output device. For example, the hardware security component **13** may include a secure non-volatile memory (NVM) **14** and a controller **15**. For example, the controller **15** may be configured to receive the processor identification from the processor, receive the at least one component identification from the one or more electronic components, and determine if a boot of the processor-based system is a provisioning boot of the processor-based system. If the boot is determined to be the provisioning boot, the controller **15** may be configured to store a security code in the secure non-volatile memory **14**, wherein the security code is based on the processor identification and the at least one component identification.

If the boot is not determined to be the provisioning boot the controller **15** may be configured to determine a platform code based on the processor identification and the at least one component identification, and determine if the platform code is valid based on a comparison with the security code stored in the secure non-volatile memory **14**. If the platform code is determined to be valid, the controller **15** may be configured to proceed to boot the processor-based system. If the platform code is not determined to be valid, the controller **15** may be configured to discontinue the boot of the processor-based system.

For example, in some embodiments of the invention if the platform code is not determined to be valid, information may be stored in the secure non-volatile memory related to the boot attempt. The disabled system may later be inspected for the boot attempt information. For example, in some embodiments of the processor-based system the controller **15** may be further configured to determine if a communication channel is present. If the communication channel is determined to be present and if the platform code is not determined to be valid, the controller **15** may send a report over the communication channel (e.g. to notify a service provider of a potential problem with the system). For example, the communication channel may be a network connection (e.g. an Ethernet connection or a WiFi connection). For example, the communication channel may be a telephone connection (e.g. a modem or a cell phone connection).

For example, in some embodiments of the processor-based system the controller **15** may be further configured to determine if the platform code needs to be validated based on information stored in the secure non-volatile memory **14**. If the platform code is determined to not need to be validated, the controller **15** may proceed to boot the processor-based system (e.g. without running the validation process). For example, after the system is paid up or after the lease or contract is fulfilled, the system may no longer need to be validated and the user may upgrade the system or change components without any involvement of the original service provider.

For example, in some embodiments of the processor-based system, the hardware security component **13** may be integrated with the processor **11** in a same package as the processor **11**. For example, the secure non-volatile memory **14** may also be integrated with the hardware security component **13** and the processor **11** in a same integrated circuit package as the hardware security component **13** and the processor **11**. For example, the hardware security component **13** and/or the secure NVM **14** may be formed on a same integrated circuit die as the processor **11**. For example, the secure NVM **14** may be an internal ROM such as an electrically erasable programmable read only memory (EEPROM) or other type of internally accessible persistent storage circuit (e.g. but externally inaccessible).

In some embodiments, the hardware security component **13** may utilize portions of the processor **11** to implement some or all of the hardware security component **13** functionality. For example, the processor **11** may include its own secure non-volatile memory **14** which may be shared with the hardware security component **13**. For example, the processor **11** may be programmed with firmware to perform the controller **15** functions of the hardware security component **13** upon power on of the processor **11**.

With reference to FIG. **2**, a processor-based system in accordance with some embodiments of the invention is configured similarly to the processor-based system of FIG. **1**, except the hardware security component **23** (including the secure NVM **24** and controller **25**) is more tightly coupled to the electronic component **22** instead of the processor **21**. For example, hardware security component **23** may be integrated with one of the electronic components **22** in a same package as the electronic component **22**. For example, the secure non-volatile memory **24** may also be integrated with the hardware security component **23** and the electronic component **22** in a same integrated circuit package as the hardware security component **23** and the electronic component **22**. For example, in some embodiments the electronic component **22** integrated with the hardware security component **23** and/or the secure NVM **24** may be a chipset component. For example, the hardware security component **23** and/or the secure NVM **24** may be formed on a same integrated circuit die as the electronic component **22**. In some embodiments, the hardware security component **23** may utilize portions of the electronic component **22** to implement some or all of the hardware security component **23** functionality.

With reference to FIG. **3**, a processor-based system **31** may include a processor **32**, a system memory **35** coupled to the processor **32**, a mass storage device **38**, and a cache memory **36**. For example, the processor **32** may be a central processing unit (CPU). For example, the system memory **35** may be a dynamic random access memory (DRAM). For example, the system memory **35** may be coupled to the processor **32** via a memory controller hub (MCH) **34**. For example, the mass storage device **38** may be a rotating media such as a hard disk drive or an optical disk drive. For example, the mass storage device **38** may be a non-rotating media such as a solid-state drive. For example, both the cache **36** and the mass storage device **38** may be coupled to the MCH via an input/output controller hub (ICH) **37**. For example, the cache **36** may include a non-volatile memory (NVM).

The processor-based system **31** may further include code stored on the processor-based system **31** to cause the processor-based system **31** to implement a hardware security agent in the processor **32**. For example, the code may be stored on the mass storage device **38**, the system memory **35**, or another memory or storage device coupled to the processor-based system **31**. For example, the code may be stored as part of a basic input/output system (BIOS) **39** coupled to the ICH **37**. Preferably, the code may be stored in a secure non-volatile memory in the processor **32**.

For example, the processor **32** may have a unique processor identification one or more of the MCH **34**, DRAM **35**, cache **36**, ICH **37**, mass storage device **38**, and BIOS **39** components may have an associated unique component identification. Other components may be coupled to the processor **32** including, for example, a graphics component, a display component, an input/output component, a network component, a global positioning system (GPS) component, and a cellular communication component, among numerous other electronic components which may find utility in an electronic system. For example, upon provisioning the processor-based system the security agent in the processor **32** may generate a security code using the processor identification and the component identifications from each of the components coupled to the processor **32** which has an associated component identification.

On subsequent boots of the processor-based system **31**, the security agent in the processor **32** may generate a platform code based on the processor identification and the available component identifications. By comparing the newly generated platform code with the previously stored security code stored in the secure non-volatile memory, the security agent may determine if the system has been altered after the prior provisioning. If the system has been altered, the security agent may halt the boot and/or attempt to send the service provider a notification over the network or through another available communication channel.

In accordance with some embodiments of the invention, one or more of the components coupled to the processor **32** may also have their own security agent in addition to the security agent in the processor **32**. For example, each of the processor **32**, the MCH **34**, the DRAM **35**, the cache **36**, the ICH **37**, the mass storage **38**, and the BIOS **39** may have an associated security agent (e.g. in a same integrated circuit package and/or formed on a same integrated circuit die as the associated device). For example, the security agent may include a secure NVM which stores a unique identifier for the associated device. For example, during a provisioning boot each of the components that has a security agent may go through the process of gathering information (e.g. the unique identifiers) from the connected components, generating a security code based on the gathered information, and storing the security code in an internal, secure NVM on the associated device. For example, during a subsequent boot each of the components that has a security agent may go through the process of validating itself in the current platform and disabling itself if the validation fails.

Each device with its own security agent may individually disable itself if the device is placed in an unauthorized system. Advantageously, by rendering more devices useless if removed some embodiments of the invention increase the hardening of the system. Each device that is disabled may have little value on the grey market value and may further discourage rogue users. The processor-based system **31** and/or the processor **32** and individual components may further include an administrative mode or alternate security code which is known, for example, to the OEM/ODM to restore the system and/or components to an operating state or to re-provision the platform. For example, the platform may be re-provisioned if during the term of a service contract the user purchases additional components or upgrades from the service provider. In some embodiments, such re-provisioning may be performed in a secure manner over a network connection (e.g. the internet), such that a user may purchase and upgrade online, install it themselves, and then authorize the new components with an automated process provided by the service provider.

With reference to FIG. **4**, in accordance with some embodiments of the invention utilizing a processor-based system may include receiving a processor identification from a processor (e.g. at block **41**), receiving at least one component identification from one or more electronic components (e.g. at block **42**), determining if a boot of the processor-based system is a provisioning boot of the processor-based system (e.g. at block **43**), if the boot is determined to be the provisioning boot, storing a security code in a secure non-volatile memory, wherein the security code is based on the processor identification and the at least one component identification (e.g. at block **44**), and booting the processor-based system (e.g. at block **45**).

If the boot is not determined to be the provisioning boot, some embodiments of the invention may further include determining a platform code based on the processor identification and the at least one component identification (e.g. at block **46**), determining if the platform code is valid based on a comparison with the security code stored in the secure non-volatile memory (e.g. at block **47**), if the platform code is determined to be valid, booting the processor-based system (e.g. at block **45**), and if the platform code is not determined to be valid, discontinuing the boot of the processor-based system (e.g. at block **48**).

With reference to FIGS. **5-7**, some embodiments of the invention may further include providing the secure non-volatile memory in a same package as the processor (e.g. at block **51**). Some embodiments of the invention may further include providing the secure non-volatile memory in a same package as one of the one or more the electronic components (e.g. at block **61**). For example, the electronic component provided with the secure non-volatile memory may be a chipset component (e.g. at block **62**). For example, in some embodiments of the invention the electronic components may include at least one of a chipset component, a memory component, and an input/output device (e.g. at block **71**).

With reference to FIG. **8**, some embodiments of the invention may further include determining if a communication channel is present (e.g. at block **81**) and if the communication channel is determined to be present and if the platform code is not determined to be valid, sending a report over the communication channel (e.g. at block **82**). For example, the communication channel may include a network connection (e.g. at block **83**). For example, the communication channel may include a telephone connection (e.g. at block **84**).

With reference to FIG. **9**, some embodiments of the invention may further include determining if the platform code needs to be validated based on information stored in the secure non-volatile memory (e.g. at block **91**), and if the platform code is determined to not need to be validated, proceeding to boot the processor-based system (e.g. at block **92**). If the platform code is determined to need to be validated, some embodiments of the invention include proceeding to validate the platform code (e.g. at block **93**).

For example, some embodiments of the invention may find utility in electronic systems which are provided to end users under a contract or service plan. For example, a pay-as-you-go financing business model similar to those presently used for cell phones and smart phones may make other electronic systems more affordable for new users who may have a desire to use a particular electronic system but cannot afford the payment up front. For example, partners in the pay-as-you-go business model may include financial institutions (banks), and internet service providers (ISPs). One specific example of this business model is the Microsoft FlexGo™ initiative.

A prepaid business model may be a specific subset of the pay-as-you-go model where the end user pays the provider upfront for certain amount of time (e.g. like cell phone minutes). The user can use the device for the specified amount of time at the end of which the device will not be operable until the user buys more time. After a certain number of hours used (e.g. a certain amount of payment), the device may become the user's possession.

A subscription model is another subset of the pay-as-you-go model where the end user agrees to a service contract with the provider (e.g. a monthly payment for an agreed to period of time). When the user fulfills the terms of the service contract, the device may become the user's possession.

Advantageously, some embodiments of the invention may support the pay-as-you-go model by making the model more attractive for both the business partners and the end users. For example, by hardening the system with the hardware security agent instead of the physical security measures, cost is reduced for the business partners and this cost saving may be passed along to the end users. Some embodiments of the invention will discourage rogue users from taking parts off a the device which is hardened (as described herein) and selling it or using it in another computer because the parts may be inoperable in other systems (and the original system may become inoperable if altered). Advantageously for the end users, their device may be upgraded (e.g. with an authorized upgrade during the contract or after they fulfill the terms of the contract with the service provider). For example, the user may be able to upgrade the processor, add memory, add I/O cards, or otherwise modify their system.

Some embodiments of the invention may include of a mix of hardware (HW) and firmware (FW) components. The HW may be realized as a micro-controller similar to, for example, a Manageability Engine (ME) in various Intel Corporation chipset products. For example, some embodiments of the invention may be implemented in the micro-code of the CPU. If the CPU gets improperly plugged into a different system, some embodiments of the invention will ensure the processor halts, rendering the system useless.

For example, a system may be built at an original equipment manufacturer (OEM) or original design manufacturer (ODM) with a specific processor, chipset, dual in-line memory module (DIMM), flash device, and IO device(s), among other components. Either the processor or the chipset may have a micro-controller HW (Agent) and may be configured to be the first piece of HW to execute (e.g. even before the host CPU core comes up during the normal boot process). The Agent may have some amount of secure read-only memory (ROM) that is not accessible to anyone outside this piece of HW. The ROM may at least a write-once ROM.

Before the system is provided to the end user, the system undergoes an initial provisioning. For example, the first boot after the system is assembled, tested and ready for packaging and delivery to the end user, the Agent may detect that it is the first boot and start the provisioning process. For example, the provisioning process may include detecting the platform components and their IDs, generating a unique platform ID based on their combination, and storing it securely.

For example, the Agent may execute a secure firmware application (App). The code of the App may be retrieved from a secure storage (e.g. an encrypted flash or an internal ROM) and may be authenticated with some standard security mechanisms. The App may gather the processor ID, chipset ID, memory ID (e.g. from a serial presence detect (SPD)), firmware hub (FWH) ID, IDs of the IO devices, and any other IDs from components which have IDs. All of the gathered IDs may be concatenated in a unique way to form the Platform ID. The different OEM/ODMs can choose their own way of generating this platform ID code. The unique platform ID code may also be encrypted using standard algorithms (e.g. chosen by the ODM/OEM) and stored in the secure ROM within the chipset (or processor).

For example, on subsequent boots the Agent may retrieve the platform ID from the secure storage and retrieve all of the available component IDs of the system. The Agent may transfer control to the boot firmware if all the OEM/ODM installed components are present (e.g. the system has not been tampered with). If the same components are not present, the Agent may enter a HW locked mode and the system will not boot an OS. In some embodiments of the invention, a critical error may be logged in the secure storage and if a network connection is present the service provider may be alerted.

For example, these checks may happen upon each reboot as long as the system is not paid for or the terms of the contract have not been fulfilled. For example, the pay-as-you-go provider (e.g. the ISP or other such entities) may use secure methods of metering and updating a flag in the secure storage to indicate if the system has been paid off in full or not. For example, when the user fulfills the terms of the service contract, a secure provisioning process from the service provider (e.g. over a network connection) may communicate with the Agent to ensure the platform ID check is not run anymore on reboots.

For example, the secure methods for the service provider may make use of the root of trust built into the hardware that will only accept a ‘payment made’ changes from a trusted OEM, whose certificate is registered on the system, and the request is duly signed by private key. For example, upon validating that the information is from a trusted OEM, the system may further make sure that the information includes valid request indicating ‘payment’ for all the features enabled. Additional vendors (e.g. for IO or add-in cards) may incorporate similar checks in a local secure storage (e.g. an option ROM). Advantageously, providing an add-in card with an ID and/or its own security agent may help ensure that the add-in cards will work only on the system they were meant for.

With reference to FIG. **10**, some embodiments of the invention for utilizing a processor-based system include initiating a reboot (e.g. at block **100**), executing a hardware agent before starting the BIOS (e.g. at block **101**), loading a firmware application from secure storage with the hardware agent (e.g. at block **102**), and authenticating the firmware application (e.g. at block **103**). The firmware application detects the platform components and collects the available component IDs (e.g. at block **104**). If the firmware application determines that this is a first boot of the platform (or an otherwise authorized provisioning boot) (e.g. at block **105**), the firmware application generates a unique platform ID based on the individual device information (the component IDs) and stores the platform ID in secure storage (e.g. at block **107**). The firmware application may then reset a flag in secure storage that indicates the system is not yet paid-in-full (e.g. at block **108**) and transfer control to the system firmware for boot (e.g. at block **109**). If the firmware application determines that the current boot is not a first boot of the platform (or otherwise not an authorized provisioning boot), the firmware application begins the next steps (e.g. at block **106**).

With reference to FIG. **11**, in some embodiments of the invention the next steps may include the firmware application retrieving the unique platform ID from the secure storage and comparing the retrieved ID with the platform components present (e.g. at block **112**). If the system has been paid in full (e.g. as indicated by a flag in the secure storage), the firmware application may transfer control to the system firmware for boot (e.g. at block **114**) without performing further validation of the platform. If the system has not been paid in full (e.g. at block **113**) but the retrieved platform ID matches the present platform configuration (e.g. at block **115**), the firmware application may transfer control to the system firmware for boot (e.g. at block **114**). If the system has not been paid in full (e.g. at block **113**) and the retrieved platform ID does not match the present platform configuration (e.g. at block **115**), the system may have been tampered with the firmware application may lock down the system and alert the server through an out-of-band (OOB) communication.

Those skilled in the art will appreciate that, given the benefit of the present description, a numerous variety of other circuits and combinations of hardware and/or software may be configured to implement various methods, circuits, and systems in accordance with the embodiments described herein and other embodiments of the invention. The examples of FIGS. **1** through **11** are non-limiting examples of suitable embodiments.

The foregoing and other aspects of the invention are achieved individually and in combination. The invention should not be construed as requiring two or more of such aspects unless expressly required by a particular claim. Moreover, while the invention has been described in connection with what is presently considered to be the preferred examples, it is to be understood that the invention is not limited to the disclosed examples, but on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and the scope of the invention.

We claim:

1. At least one non-transitory computer readable storage medium comprising a set of embedded controller firmware instructions which, if executed by an embedded controller that is integrated into a computing platform, cause the embedded controller to:

determine a platform code based on a processor identification of a processor and a component identification of at least one electronic component upon a non-provisioning boot of the processor-based system; and

determine if the platform code is valid based on a comparison with a stored security code wherein the security code is based on a processor identification of the processor and an a component identification of the at least one electronic component upon a provisioning boot of the processor-based system.

2. The medium of claim **1**, further comprising wherein the firmware instructions, if executed, cause the embedded controller to boot the processor-based system if the platform code is determined to be valid.

3. The medium of claim **1**, further comprising wherein the firmware instructions, if executed, cause the embedded controller to discontinue the boot of the processor-based system if the platform code is invalid.

4. The medium of claim **1**, further comprising wherein the firmware instructions, if executed, cause the embedded controller to store information related to the boot attempt if the platform code is invalid.

5. The medium of claim **1**, further comprising wherein the firmware instructions, if executed, cause the embedded controller to perform a validation test on the at least one electronic component based on a second stored security code.

6. The medium of claim **5**, further comprising wherein the firmware instructions, if executed, cause the embedded controller to disable the at least one electronic component if the validation test fails.

* * * * *